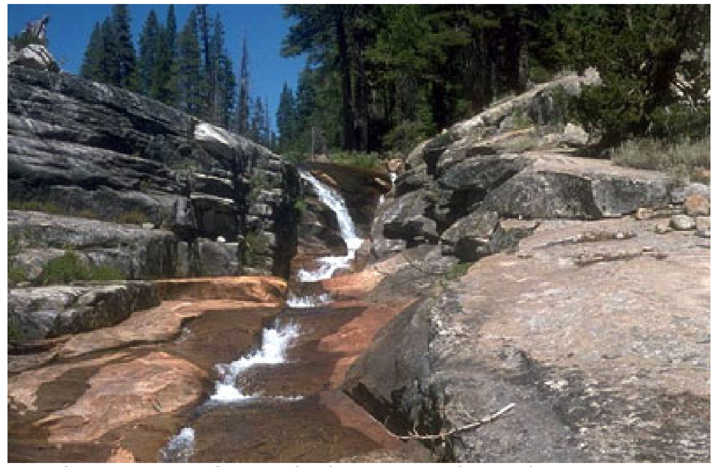
Watershed Quality and Assessment

Watersheds across California are immensely diverse, from the wet coastal watersheds on the North Coast to the arid desert landscapes in portions of southern California. Watersheds may be linked to distant parts of the State through creeks, river channels, canals, reservoirs, and pipes (e.g., from the snows of Mt. Shasta to the lawns of San Diego). They connect issues such as water quality and water supply, floodplains to land use, instream and upslope features and uses, and natural ecosystems to man-made ones. They connect across artificial boundaries, such as local and State political jurisdictions or private and public ownerships. This complex interconnectivity creates a considerable management challenge regarding the resources within each watershed.



Blue Canyon, Placer County, California. Photo © Br. Alfred Brousseau, Saint Mary's College.

The area of land that drains water downslope to a receiving water body at its lowest point is referred to as a watershed. A watershed is a geographic unit, varying in size, that collects, stores, and releases water. California watersheds comprise a vast mosaic of ecosystems, resources, and land uses. That same diversity makes the problems and issues facing each watershed unique, creating a great challenge for managing the natural resources within them. Over the past 15 years or more, watersheds have increasingly become the focus of the following issues:

- social organization for natural resource protection and improvement;
- regulatory programs for the protection of water quality;
- regulatory and voluntary restoration programs for the improvement of aquatic habitat of listed anadromous salmonids;
- public and private land management efforts to protect and enhance natural resources; and
- public and private efforts to assess the environmental health of landscapes and streams.

A watershed is a geographic unit, varying in size that collects, stores, and releases water.

The first four of these areas have been addressed in Chapter Seven, Governance: Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management. This chapter of the Assessment (Chapter Four, Soil and Water: Conservation and Maintenance of Soil and Water Resources) addresses the last of these areas.

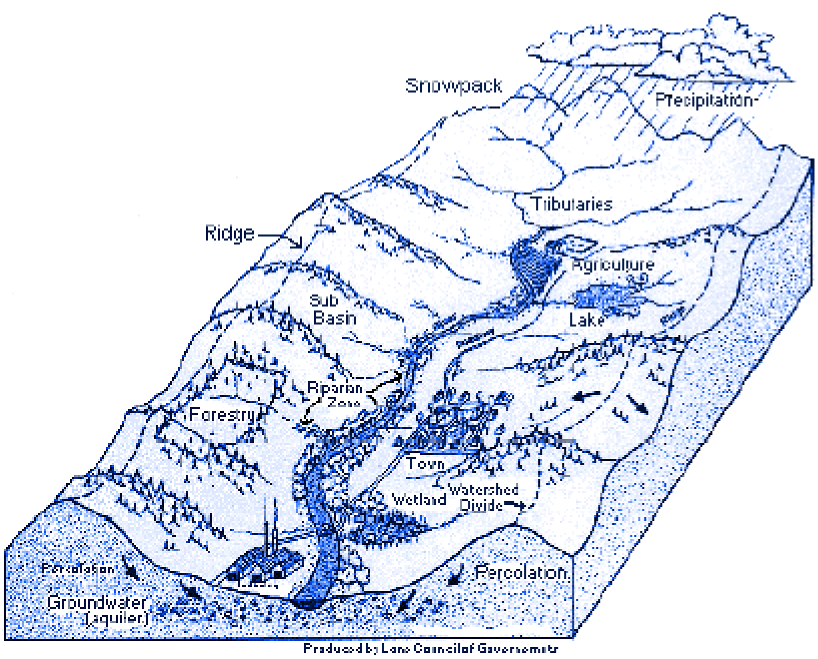
The "Watershed Quality and Assessment" chapter begins with a biophysical description of watersheds and a regional perspective of watersheds across California. A discussion follows concerning key processes that influence watersheds. Third, there is a brief overview of beneficial uses and the influence of land use on water quality. In order to provide a more detailed understanding of watershed processes and functions, this discussion is followed by a presentation on the five key watershed products:

water flow, water temperature, sediment, large woody debris (LWD), and nutrients. From here, the issues surrounding Cumulative Watershed Effects (CWE) are examined, followed by a discussion on watershed assessment and restoration activities within California. The chapter concludes with an evaluation of the current limitations to watershed analysis.

Watersheds: the physical setting

The major watersheds across California differ distinctly in climate, geology, ecosystems, and land use. What is common among these watersheds is that all of the major rivers that drain them originate in forested or vegetated landscapes. Accordingly, the forest lands of California play an important role in providing clean water for a variety of uses (agriculture, domestic water supply, fish and wildlife, recreation, hydropower, etc.). The forest filters and meters the movement of rainfall, and at the higher elevations the forest snow pack acts as a natural reservoir. The rainfall replenishes aquifers and delivers water to streams (Figure 1). Forest and rangeland vegetation and soils are valuable for absorbing snowmelt and rain, storing moisture, cooling and cleansing water, and slowing storm runoff. This vegetation also helps to hold soil and hillslopes in place.

Figure 1. Diagram of the features and processes that are found in a watershed



Source: U.S. Environmental Protection Agency, 2002

Watersheds vary in size and can be scaled up or down (aggregated or disaggregated) to assess different biophysical factors or to analyze and address problems or opportunities of varying scope. For example, from the 14,000-square-mile watershed of the San Joaquin River, it is possible to focus down to the 700-square-mile Mokelumne River watershed, the 75-square-mile Middle Fork of the Mokelumne watershed, or to the 22-square-mile Forest Creek watershed.

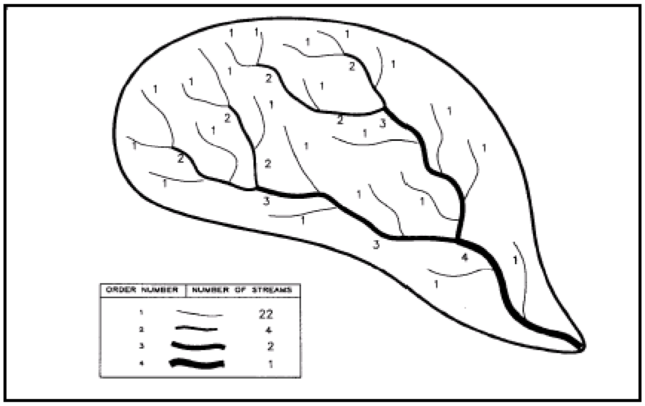
At the largest scale, watersheds are categorized by major hydrologic regions of California based on the size of stream or river they include. These regions are shown in Figure 2. Each hydrologic region contains many individual watersheds, but they share similarities with respect to climate, geology, and land use.

Figure 2. Major hydrologic regions of California

Source: California Department of Water Resources (DWR), 1998

Stream channels exhibit a wide variety of morphologies that result in a broad array of stream types throughout a watershed. Channel classification is performed to take the continuum of conditions that are found in a stream system and group channel segments by function and form. Stream order is one of the commonly used channel classification systems. Stream order correlates with drainage area and can serve as a proxy for stream size. In the Strahler stream order, two first order channels will combine to form a second order channel (Figure 3) (Strahler, 1957). This process is repeated throughout the channel network (California Department of Fish and Game (DFG), 1998).

Figure 3. Classification of stream network



Note: In the Strahler stream order, two first order channels will combine to form a second order channel (Strahler, 1957). This process is repeated throughout the channel network.

Source: DFG, 1998

Regional perspective of California watersheds

Watersheds across California are immensely diverse, from the wet coastal watersheds on the North Coast to the arid desert landscapes in portions of southern California (Table 1). This biophysical diversity creates a broad range of uses supported by California's watersheds and a considerable resource management challenge within each watershed.

Table 1. California watershed variability

Region 1*	Size (million acres)	Major rivers, waterbodies	Stream miles (thousands)	Precip. And Runoff maf	Dominant vegetation (percent)	Agriculture/Urban (percent)
North Coast watersheds	12.4	Klamath, Eel, Trinity, Salmon, Smith, Russian	22.1	55.9, 28.9	Conifer (57), Hardwood (17), Herbaceous (7), Shrub (11),	Agriculture (5), Urban (1)
Sacramemto River Basin	17.4	American, Pit, Yuba	32.8	52.4, 22.4	Conifer (38), Hardwood (15), Herbaceous (10), Shrub (15)	Agriculture (15), Urban (3)
San Joaquin and Tulare Lake	20.6	Consumnes, Mokelumne, Stanislaus, Tuolumne, Merced	41.1	35.7, 11.2	Conifer (20), Hardwood (13), Herbaceous (22), Shrub (6)	Agriculture (29), Urban (4)
Eastern Sierra	21	Owens, Truckee, Carson, and Walker. Lake Tahoe and Mono Lake	33	15.3, 3.2	Desert (62), Shrub (16), Conifer (10)	Agriculture (2), Urban (2)
Central Coast and San Francisco Bay Region	10.2	Santa Ynez, Carmel, Salinas, Big Sur, Napa, Petaluma, Walker Creek, Lagunitas Creek, Alameda Creek	21.8	17.8, 3.7	Hardwood (20), Herbaceous(29), Shrub (24)	Agriculture (8), Urban (11)
South Coast and Colorado River watersheds	19.8	Colorado, San Diego, Santa Margarita, San Jacinto, and the Los Angeles	33.9	15.1, 1.4	Desert (52), Shrub (18)	Agriculture (7), Urban (11)

**See figure 2 for geographic reference*

Source: Compiled by the Fire and Resource Assessment Program (FRAP) from Natural Resources Conservation Service, 2003; U.S. Geological Survey, 2003; FRAP, 2002a and DWR bulletin 160-98.

The largest area is the Eastern Sierra, but most stream miles are found in the combined San Joaquin/Tulare Lake area, followed by the Sacramento region. Dominant vegetation varies from conifer to desert. The largest agricultural cover is found in the San Joaquin/Tulare Lake area, followed by the Sacramento River Basin. The largest urban land cover is seen in the South Coast/Colorado River watersheds and the Central Coast/Bay Area. Key watershed issues always vary. These are summarized in Table 2.

Table 2. Watershed issues in California

Region	Key Watershed Issues of Concern
North Coast watersheds	Watershed impacts of land management (erosion and sedimentation, water diversions, removal of streamside vegetation, pesticide and herbicide use) resulting in degradation of instream aquatic habitat, impairment of anadromous salmonid fisheries, and threats to drinking water quality; and export of water.
Sacramento River Basin	Watershed impacts of land management (erosion and sedimentation, water diversions, removal of streamside vegetation, pesticide and herbicide use) resulting in degradation of instream aquatic habitat, impairment of anadromous salmonid fisheries, and threats to drinking water quality; water supply quantity and reliability; Bay-Delta ecosystem protection and restoration; population growth and development; and wildland fire.
San Joaquin and Tulare Lake	Watershed impacts of land management (erosion and sedimentation, water diversions, removal of streamside vegetation, pesticide and herbicide use) resulting in degradation of instream aquatic habitat, impairment of anadromous salmonid fisheries, and threats to drinking water quality; water supply quantity and reliability; Bay-Delta ecosystem protection and restoration; population growth and development; and wildland fire.
Eastern Sierra	Watershed impacts of land management (erosion and sedimentation, water diversions, removal of streamside vegetation, herbicide use) resulting in degradation of aquatic habitat; water supply, water diversions (Mono Lake), water turbidity (Lake Tahoe), and wildland fire.
Central Coast and San Francisco Bay Region	Watershed impacts of land management (erosion and sedimentation, water diversions, removal of streamside vegetation, pesticide and herbicide use) resulting in degradation of aquatic habitat, impairment of anadromous salmonid fisheries, and threats to drinking water quality; water supply quantity and reliability; Bay-Delta ecosystem protection and restoration; population growth and development; and wildland fire.
South Coast and Colorado River watersheds	Water supply for domestic, agricultural, and environmental uses.

Key watershed processes

In all watersheds, physical and biological processes combine to create the ecological condition of a watershed and define the services (e.g., beneficial uses) that a watershed can support. The natural variability of these processes in space and time gives rise to a diverse array of environmental conditions across a watershed. In many cases, the relationship between the physical process (hillslope erosion, for example) and the eventual biological response (smolt production) is poorly understood. The high variability combined with a limited understanding of watershed dynamics further complicates land management decisions. However, there are some basic principles that help explain the diversity of conditions that occur across a watershed.

In all watersheds, physical and biological processes combine to create the ecological condition of a watershed and define the services that a watershed can support.

Changes in the quantity and quality of water often directly affect the health of the watershed. Land management activities and land use changes affect soil and water resources. Ignoring these effects can lead to unwanted consequences upslope and downstream. A healthy watershed will reveal the beneficial linkages between upland use and downstream effects—the basic maxim of watershed management. In an unhealthy watershed, these linkages are not well-valued, known, or addressed.

Key factors that influence watersheds include basin geomorphology, hydrologic patterns, water quality, riparian characteristics, and habitat characteristics (Table 3). These components are hierarchical, meaning that basin geomorphology can exert a strong influence on water quality; however, water quality does not influence basin morphology.

Table 3. Hierarchical controls on watersheds (broadest first)

Component	Factors considered	Sphere of influence
Basin geomorphology	Physiographic and geologic setting; Significant geomorphic processes; Natural disturbance regimes	Affects all factors except climate
Hydrologic patterns	Discharge pattern flood characteristics and water storage; Bedload and sediment routing; Subsurface dynamics	Channel geomorphology and other physical characteristics, some aspects of chemical regime, riparian forest, and in-channel community dynamics
Water quality	Biogeochemical processes; Fundamental parameters	Feedbacks to terrestrial vegetation and direct effects on chemical and biotic characteristics
Riparian forest characteristics	Light and temperature; Nutrient inputs; Woody debris source	Most aspects of the physical, chemical, and biotic characteristics
Habitat characteristics	Fish habitat preferences; Fish community dynamics; Spatial and temporal dynamics; Woody debris accumulations; Wildlife communities; Trophic pathways	Influence in other biotic communities in stream and strong feedbacks to physical, chemical, and terrestrial dynamics

Source: Naiman et al., 1992

In many ways, streams integrate the environmental conditions (physical and biological, natural and human-caused) across a watershed. As such, stream characteristics have been shown to be good indicators of watershed condition (Naiman et al., 1992). While land use activities can affect stream characteristics, there are again some basic principles that are thought to control the distribution of channel types in a watershed (Naiman et al., 1992; Montgomery and Buffington, 1998). The variety of stream channels can be classified based on geology, topography, climate, and stream size. The combination of these basic factors helps to explain the distribution of different stream types within a watershed. For example, in coastal watersheds, low order streams (e.g., first and second order) are typically steep, and channel confinement restricts channel migration. In basins with high precipitation, these low order streams can represent more than 70 percent (by length) of the channel network. Typically, they occupy the headwaters of a watershed and are primary conduits for delivering sediment, water, wood, and nutrients to the main channels. Management of the upper portions of watersheds can be important in controlling the amount, timing, and quality of water that is delivered to the lower reaches of a basin.

Disturbance in a watershed comes from both natural events (e.g., intense precipitation, flooding, wildfires, mass wasting, etc.) and from land management activities. Understanding the timing and frequency of disturbance events places the magnitude from any single event into a watershed perspective (Naiman et al., 1992; Benda, 1998). In general, low order streams experience less frequent disturbance but at a higher magnitude. Higher order streams drain larger catchment areas and thus integrate environmental conditions. This factor results in more frequent occurrence of disturbance, but of a lesser magnitude.

Understanding the timing and frequency of disturbance events places the magnitude from any single event into a watershed perspective.

The degree of disturbance in a watershed can be influenced by the continuing impacts of things in the past (legacies) and current management activities. Current conditions in California’s watersheds continue to reflect the legacy of historical land uses, particularly heavily logged or grazed lands, intensive agriculture, abandoned mines, and development. During the era of California’s rapid economic growth and settlement, resource extraction usually was maximized, while resource stewardship and sustainability were not emphasized. For example, there is a legacy of old logging and rural subdivision roads built before improved road design and construction standards and newer technologies. If the road infrastructure was presently being built, roads would be fewer in number and of lower impact. Upslope and in-channel sediment storage sites from past human-caused disturbances are known to deliver sediment into the stream system for decades or even centuries.

Another example of enduring land use impacts is historic mining. Mining's legacy can be seen in the permanent alteration of the Sacramento River due to hydraulic mining, the dredger tailings lining many flood plains, and the abandoned hard rock mines discharging acid mine drainage into rivers (Mount, 1995). Abandoned mines represent some of California's highest priority Superfund sites and biggest cleanup challenges. California has thousands of inactive and abandoned mines. Toxic metals are released from the mine tailings through oxidation, acidifying surface and groundwater and in some areas sterilizing the aquatic habitat downstream. The mining-related metals most often exceeding water quality criteria are cadmium, copper, lead, mercury, and zinc (California State Water Resources Control Board (SWRCB), 2000a).

Today's management activities can impact many of the basic elements in a watershed and adversely affect water quality. Removal of streamside vegetation can reduce shade and inputs of woody debris to streams. Certain types of agriculture can reduce soil permeability and accelerate erosion. Development may create large areas of impervious surfaces that increase the rate of water delivery to streams, potentially resulting in flooding. Development also removes vegetation and fragments remaining vegetation patches, thus reducing the amount and connectivity of habitat in a watershed. Roads can be a source of both chronic and episodic sediment inputs to streams. In addition, roads that are poorly maintained or improperly constructed can channel water directly to streams, thus affecting the timing, frequency, and magnitude of peak flows during storm events. All of these activities, by themselves or cumulatively, can alter the way a watershed functions. The key question is whether disturbance from management activities exceeds the range of natural variation.

Better land management practices and increasing levels of stream and watershed restoration efforts are contributing to recovery in many watersheds. Examples of these efforts include road upgrades and decommissionings, removal of road-related fish passage barriers, installation of instream fish habitat structures, replanting and retaining riparian vegetation, etc. While little formal evaluation or quantification of the contributions of these efforts to recovery has been made, there is a general consensus that many of these efforts have made important contributions.

Land management and water quality in forest and range watersheds

Water quality is described in terms of the beneficial uses of water and the level of quality needed to support those uses.

Water quality is a product of both natural and human activity. Climate, geology, soils, and plant and animal communities all form a background to the impact on water quality from forestry, farming, industry, and homes. The condition of water quality in a watershed reflects the history of past land uses and natural disturbances. Water quality is described in terms of the beneficial uses of water and the level of quality needed to support those uses. The concept of beneficial use places a value on water. Beneficial uses and standards for their protection have been designated by Regional Water Quality Control Boards (RWQCBs) for river basins in California (see the Assessment document Institutional Framework: Governance Shifts during the 1990s). Within any given watershed, there are often many beneficial uses for a single resource. For example, beneficial uses of water in the Gualala River Watershed include the following (see North Coast Regional Water Quality Control Board for more information on beneficial uses).

- Municipal and Domestic Supply;
- Agricultural Supply;
- Industrial Service Supply;
- Recreational Uses;
- Commercial and Sport Fishing;
- Cold Freshwater Habitat;
- Wildlife Habitat;
- Rare, Threatened, or Endangered Species;
- Migration of Aquatic Organisms;
- Spawning, Reproduction, and/or Early Development; and
- Estuarine Habitat.

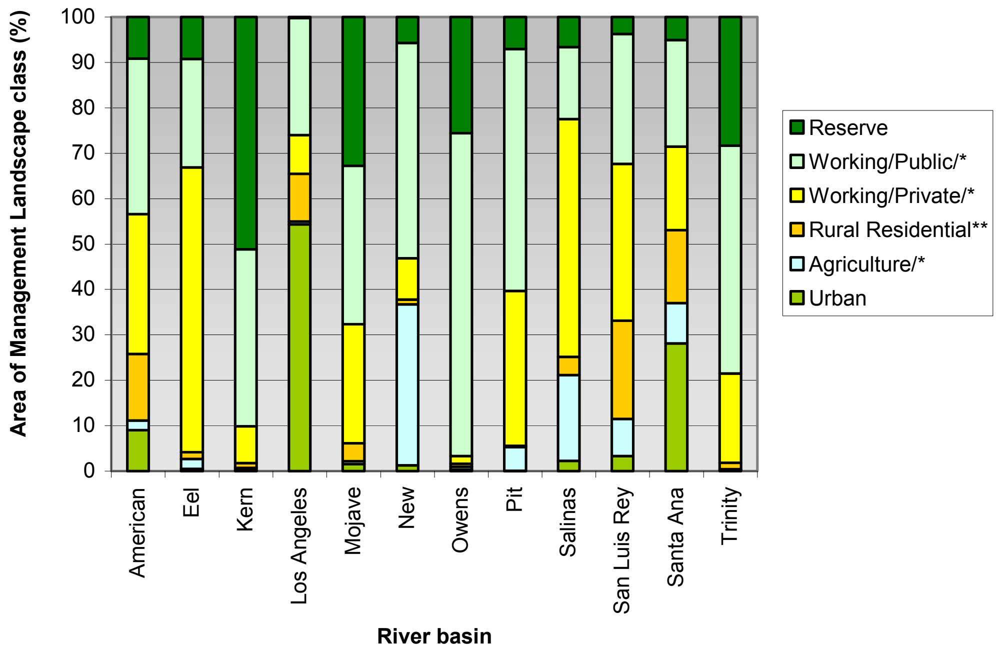
Importance of land use mix on landscape of watersheds

The knowledge of how land use within a watershed affects water quality is fundamental to understanding watershed condition. Different watersheds have different mixes of land uses and management goals. The different management classes influence watershed conditions, potential nonpoint source pollutants, and instream water quality as well as levels of financing for protection and restoration investments.

The mix of land uses in any one watershed largely determines the levels of protection from human disturbances and the potential impacts from the disturbances that do occur (Figure 4). Using the concept of the Management Landscape (land use, ownership, and population density), forests and rangelands can be grouped into classes that broadly describe how land is used and managed, thus producing a basis for understanding the interactions of land use and watershed conditions.

Each type of Management Landscape class is indicative of a different land use mix and potential impact on watershed conditions. The general classes are Reserve, Working, Rural Residential, Agriculture, and Urban. Each class also has Public or Private ownership distinctions.

Figure 4. Percentage area of Management Landscape classes by selected watershed basins



**Sparsely populated*
***includes Working/Public/Rural Residential, Working/Private/Rural Residential, and Agriculture/Rural Residential*
Source: FRAP, 2002b

Reserve lands, such as national parks and wilderness areas, are permanently managed consistent with statutory designations, which often have strict limits on management activities. Typically, these lands' ecological structures and processes remain intact and function within their natural range of vegetation. Generally, Reserve lands contribute positively towards water quality and aquatic habitat.

Working landscapes have a wide range of historical and current watershed conditions. Lands may have conditions caused by past practices, such as sediment from roads or damaged hillsides, that continue to cause problems. Other lands may have minimal disturbance with little or no impacts on water or soil quality. In recent years, the management focus on commodity production of timber and livestock has declined and practices protecting water quality have improved. Some private lands are more intensively managed resulting in a greater potential for water quality impacts, yet there are increased efforts to protect water quality. These efforts on both public and private working landscapes have been guided by standards implemented under State and federal clean water laws.

Rural Residential lands have a low density of housing structures (densities of more than one housing unit per acre but less than one housing unit per 20 acres) but still retain wildland characteristics. These lands have resource values, but management is more oriented towards open space, viewsheds, places of rural lifestyle, or recreation than commodity production or ecological integrity. Rural Residential lands introduce complex urban impacts to a watershed including permanent road systems that alter overland flow of stormwater runoff, fertilizer, herbicide, and pesticide residues, wastes from human activities, fragmentation of contiguous habitats, and the introduction of non-native plant and animal species.

Agricultural lands refer to areas where natural vegetation has been replaced by irrigated crops and orchards. Urban lands are those lands having housing densities greater than one housing unit per acre or intensive commercial or industrial uses. Water quality impacts from these land uses are beyond the scope of this assessment. However, common degradations associated with these land uses include exposure of soil to erosion, introduction of contaminants into waterways, modification of watercourses, and removal of natural vegetation resulting in increased rates and volume of stormwater runoff. These can have substantial impacts on watershed conditions, particularity in comparison to lands with limited human disturbance.

Trends in amphibian and salmon populations

Little comparative baseline data is available to address long-term amphibian population trends in the western United States and California. True frog and toad species have exhibited the most significant declines. Conservation practices that were previously thought effective, such as setting aside lands from development or reliance on parks or other reserved lands, may not provide the desired results in the face of ecosystem-wide or trans-regional effects. Forty percent of the toad species (four of ten) and 88 percent of the native frog taxa (seven of eight) have been removed from at least 45 percent of their historic California distribution (Jennings, 1995; Veirs and Opler, 1998). See

The documentation of an entire frog fauna declining in a large, diverse region is unprecedented. It is likely that a number of different factors are contributing to the documented declines. One possible explanation suggests that the long-term cumulative effects of multiple factors, where natural low points in amphibian population cycles synergize with widespread environmental alterations (e.g., extended drought, chemical pollutants, predation by and competition with non-native species, and disease) will create extinction events (Jennings, 1996; Drost and Fellers, 1996). See Population Status of Native Species. Recolonization of areas formerly occupied by some Sierra Nevada frog species is unlikely due to the widespread loss of populations and the presence of introduced predators (salmonids and char) (Bradford et al., 1993; Jennings, 1996). See Population Status of Native Species.


Salmon, Sacramento River.

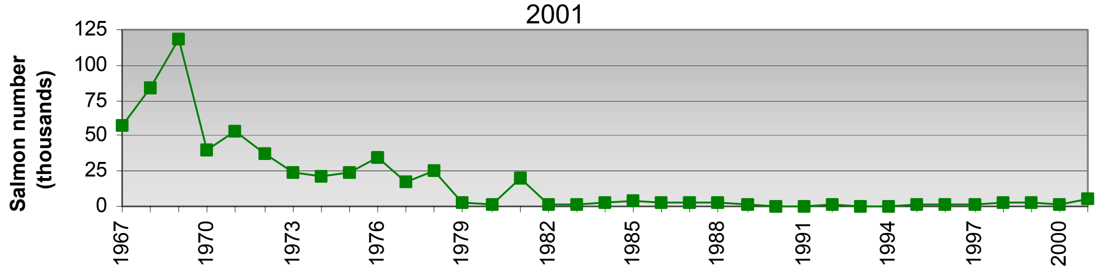
In a review of currently unlisted amphibian and reptile species, Jennings and Hayes (1994) concluded that 48 of the 80 taxa examined warranted reconsideration of their status. See Population Status of Native Species. Species occurring in aquatic habitat types such as springs, seeps, marshes, and small headwater streams are at the greatest risk for continued population decline. Degradation and reduction of aquatic habitats has occurred Statewide, but some regions have experienced greater levels of habitat loss.

Beyond amphibians, the beneficial uses of water in forested watersheds receiving the most attention in the last decade in California relate to fish and fish habitat. This is especially true of salmon. The ability of a watershed to produce juvenile salmon is largely a function of the quality and quantity of stream habitat conditions, including water quality and quantity. Important elements of water quality include temperature within a suitable range that corresponds with migration, egg development, growth of young, and the production of invertebrates as food sources. The extent to which water quality and availability issues influence estimated annual escapement of adults and numbers of juveniles (smolts) produced is not readily separated from other environmental conditions. However, water quality and quantity are clearly some of the most fundamental measures of habitat suitability and ultimately salmonid production.

The RWQCB designates several water bodies with salmon populations as impaired based on water quality concerns that arise from unacceptable levels of sediment load, elevated water temperature, pollutant occurrence, and other factors. Eight water bodies within the range of the southern Oregon/northern California Coast population of Coho salmon have been designated as impaired by the SWRCB and Environmental Protection Agency under section 303(d) of the federal Clean Water Act (CWA). The primary basis for listing the Mattole, Eel, Van Duzen, Mad, Shasta, Scott, Klamath, and Trinity River basins as impaired is excessive sediment load and elevated water temperatures.

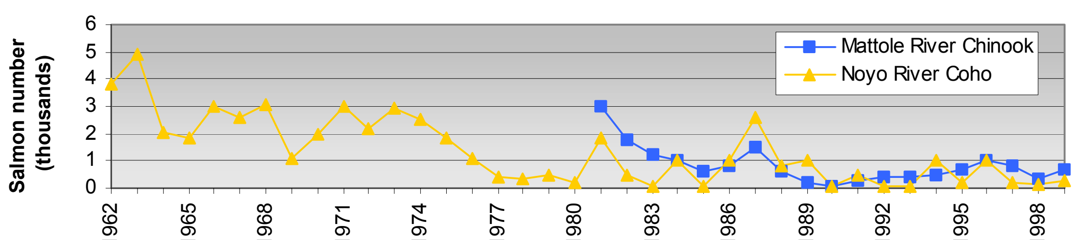
Annual estimates of salmon population levels exhibit marked variation due to a large number of interacting environmental conditions. These include specific stream habitat availability to accommodate freshwater life history requirements, water quality and availability, rainfall pattern as an influence on stream flow and juvenile migration rate, oceanic conditions during early residence, level of commercial and recreational harvest, and historic and current land use activities (e.g., agriculture, timber management, and urbanization). These environmental conditions and others have resulted in long-term downward trends in population for specific salmon stocks (Figure 5, Figure 6) and for some, formal listing under the California and/or federal Endangered Species Act.

Figure 5. Annual adult winter chinook salmon returns, Sacramento River, Red Bluff Diversion Dam, 1967-2001



Source: DFG, Native Anadromous Fish and Watershed Branch, 2002

Figure 6. Annual adult salmon returns, Noyo River coho and Mattole River Chinook, 1962-1999



Source: Southwest Fisheries Science Center, 2001; Downie et al., 2002

Status of water quality in forested watersheds

The SWRCB and its nine RWQCBs establish water quality standards and compliance for California's waterways. Every two years, the RWQCBs identify water bodies with impairments to beneficial uses using a method termed Total Maximum Daily Load (TMDL). This process identifies miles impaired, pollution types, and pollution sources. The RWQCBs then develop implementation plans to improve water quality. A review of the 2002 TMDL impairment lists reveals that California has over 26,000 miles of impaired streams. This represents about 14 percent of the total miles of streams and rivers in California. Although not all water bodies have been monitored to assess water quality status, this list represents a starting point from which to begin the assessment of Statewide water quality.

Impairment information for RWQCB watersheds provides a description of the cause of pollution that results in impairment. Most watercourses have many different potential causes. Silviculture, rangeland grazing, and agriculture were sometimes listed as at least one of the causes of pollution impairment (Table 4). The high percentage of impairments identified as unknown indicates the lack of certainty in identifying nonpoint source pollution sources.

Figure 7 shows a regional review of the percentage of impaired water bodies where silvicultural or rangeland grazing activities are one of the many causes of pollution. Over 60 percent of the impaired water bodies in the North Coast list silviculture as one of the causes of pollution. Rangeland grazing activities are one listed cause of impairment on approximately 42 percent of the impaired waterbodies in the Lahontan RWQCB region (Sierra Nevada Range).

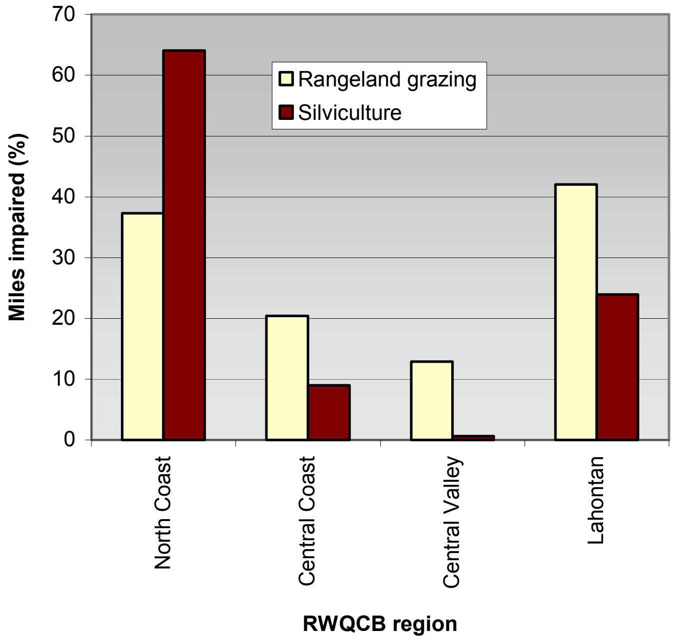
Table 4. Sources* of nonpoint pollution in California's impaired lakes, wetlands, and rivers, 2002

General pollution source	Lakes and reservoirs	Freshwater wetlands	Rivers and streams
	Acres		Miles
Agriculture (non-rangeland	25,616	73,598	10,638
Rangeland grazing	113,569		8,278
Construction	88,285	62,590	6,702
Silviculture	106,068		13,374
Habitat modification	93,932		19,723
Hydromodification	89,467		15,598
Industrial/municipal point sources			2,938
Land disposal	23,600		1,596
Marinas	108,682		N/A
Unknown sources	192,533	62,590	19,042
Other	155,925	65,636	9,562
Resource extraction	101,202		6,675
Urban runoff	112,970		1,939

** Most water body have more than one pollution source, therefore miles impaired by each pollution source do not add up to total miles impaired*

Source: Compiled by FRAP from SWRCB, 2000b

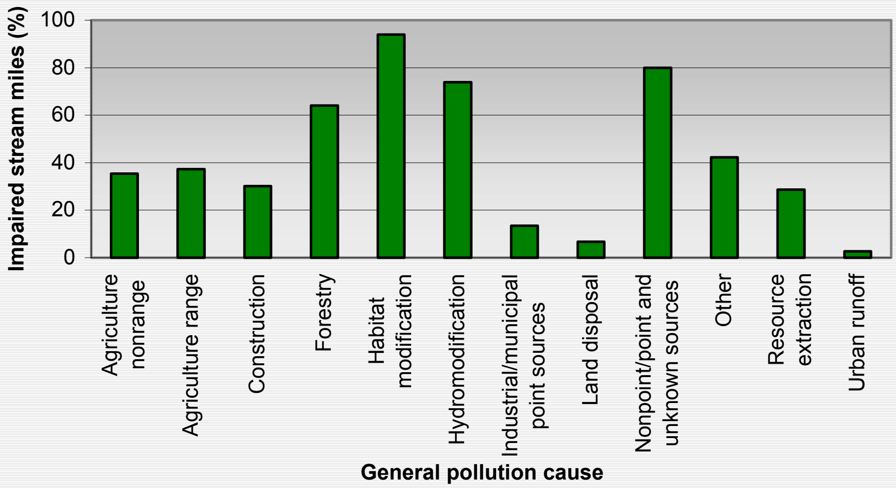
Figure 7. Percentage of impaired river and stream miles with silviculture or rangeland activities as a cause of impairment, by RWQCB, 2002



Source: Compiled by FRAP from SWRCB, 2000b

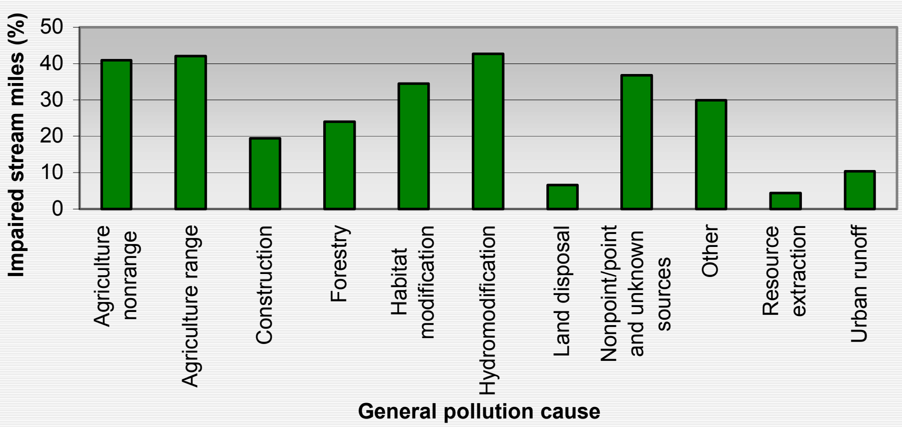
Comparison of water quality impariments between the North Coast (North Coast RWQCB) and eastern Sierra (Lahontan RWQCB): The following graphics highlight differences between the North Coast and the eastern Sierra in terms of the sources of water quality impairments. In the North Coast, silviculture is a predominant land use. Its watersheds reflect the past history of activity that, when combined with natural distubances and current land use, has led to impairments for sediment, habitat alteration (including stream temperature), and, to a minor extent, nutrients. The eastern Sierra also has a long history of timber production; however, the underlying geology is more resistant to erosion and, as a result, sediment is not as significant an issue. Other impairments are associated with mining, urbanization, and ground water extraction.

Figure 8. Percentage of total impaired stream miles by general pollution cause, North Coast RWQCB region, 2002



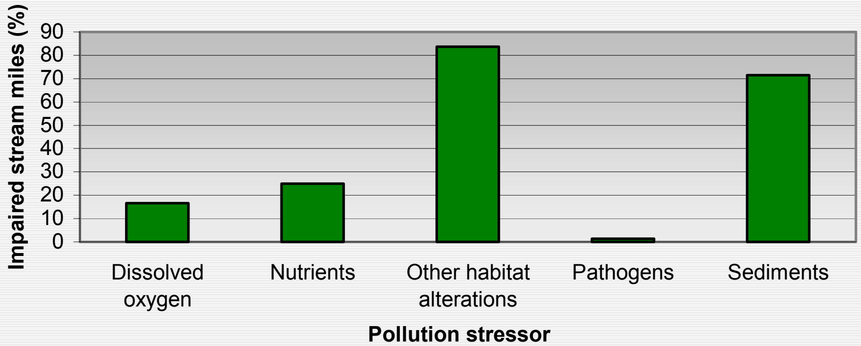
Source: SWRCB, 2000b

Figure 9. Percentage of total impaired stream miles by general pollution cause, Lahontan RWQCB region, 2002



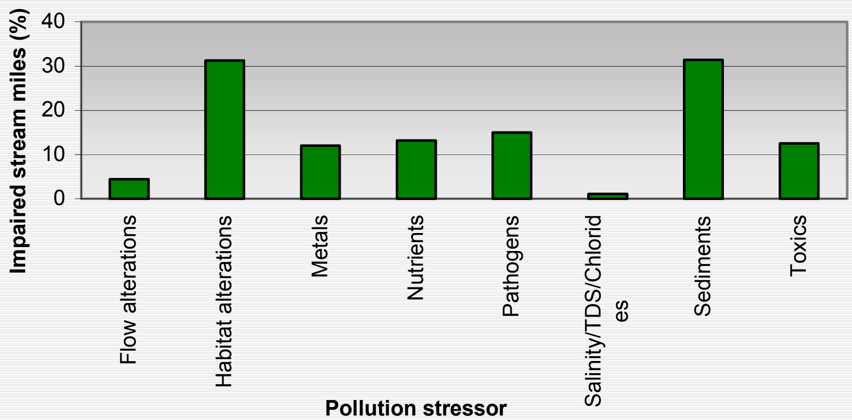
Source: SWRCB, 2000b

Figure 10. Percentage of total impaired stream miles by pollution stressor, North Coast RWQCB region, 2002



Source: SWRCB, 2000b

Figure 11. Percentage of total impaired stream miles by pollution stressor, Lahontan RWQCB region, 2002



Source: SWRCB, 2000b

Governance and the protection of water quality and related values

Governance is the framework of laws and institutions through which decisions are made about use, management, investment, and conflict resolution.

Governance is the framework of laws and institutions through which decisions are made about use, management, investment, and conflict resolution in California's forests and rangelands. The framework includes the legislative, executive and judicial branches of government. These occur at various levels—federal, State, regional, and local. Private market institutions, voluntary associations like watershed groups, and international forums are also involved.

Numerous federal and State laws relate to protection of water quality and associated values (see the Assessment document Legal Framework). Public lands are currently subject to restrictions that curtail timber harvesting, grazing, and other commodities. Management on privately-owned forests and rangelands also are heavily influenced by regulation or voluntary frameworks. Often similar to management guidelines on public lands, they include the following measures:

- plans to protect and restore fish and fish habitat;
- landscape level environmental review such as watershed assessment or CWE analysis;

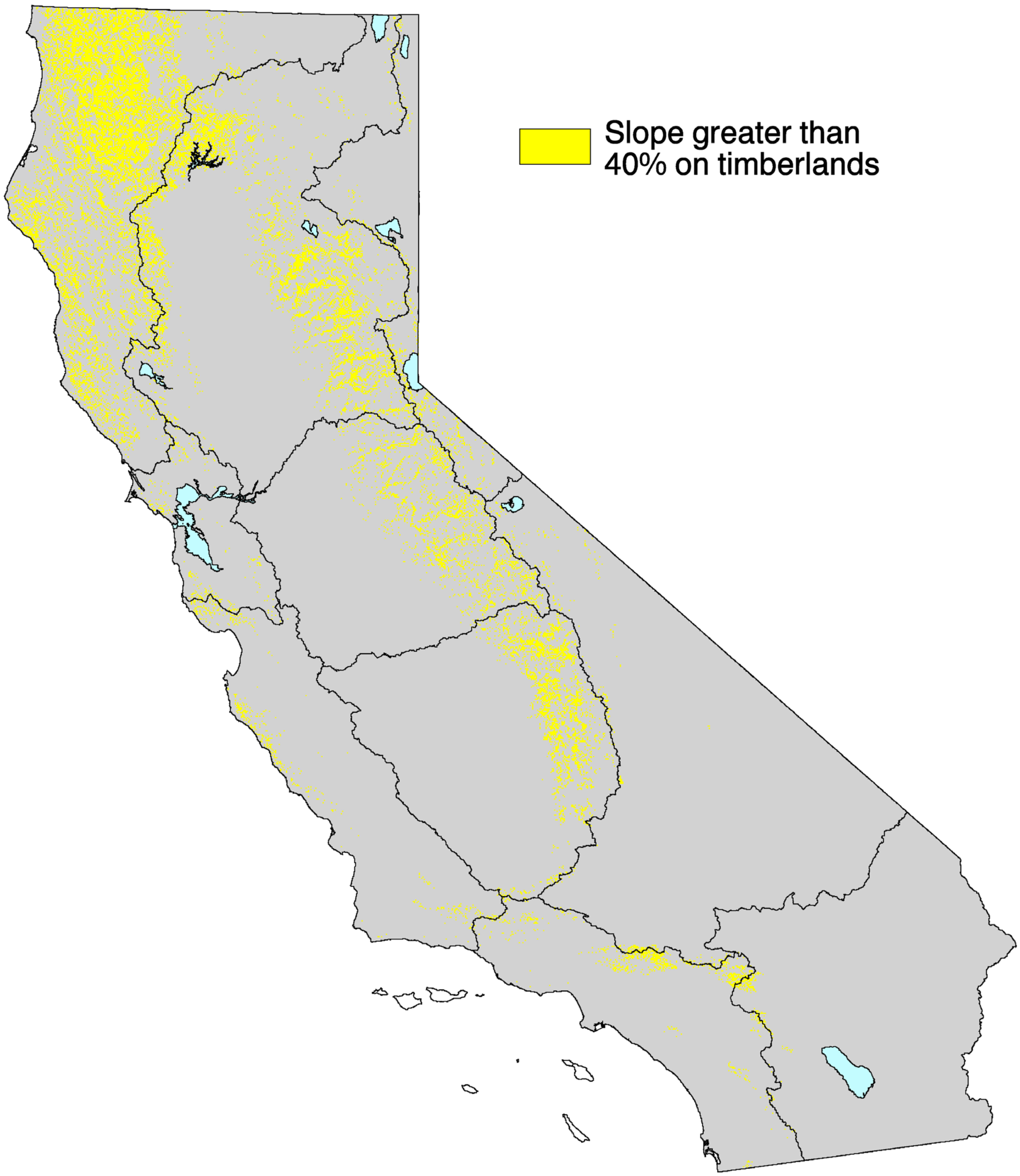
- California State Board of Forestry and Fire Protection (BOF) rules requiring consideration of sustained growth and timber harvest;
- development of plans that address threatened and endangered terrestrial and aquatic species;
- application of California Environmental Quality Act requirements to Fish and Game Stream Crossing Permits; and
- stronger application of federal CWA requirements by RWQCBs.

South Fork Eel River, California. Photo: Marc Hoshovsky, Department of Fish and Game.

Identifying sensitive areas

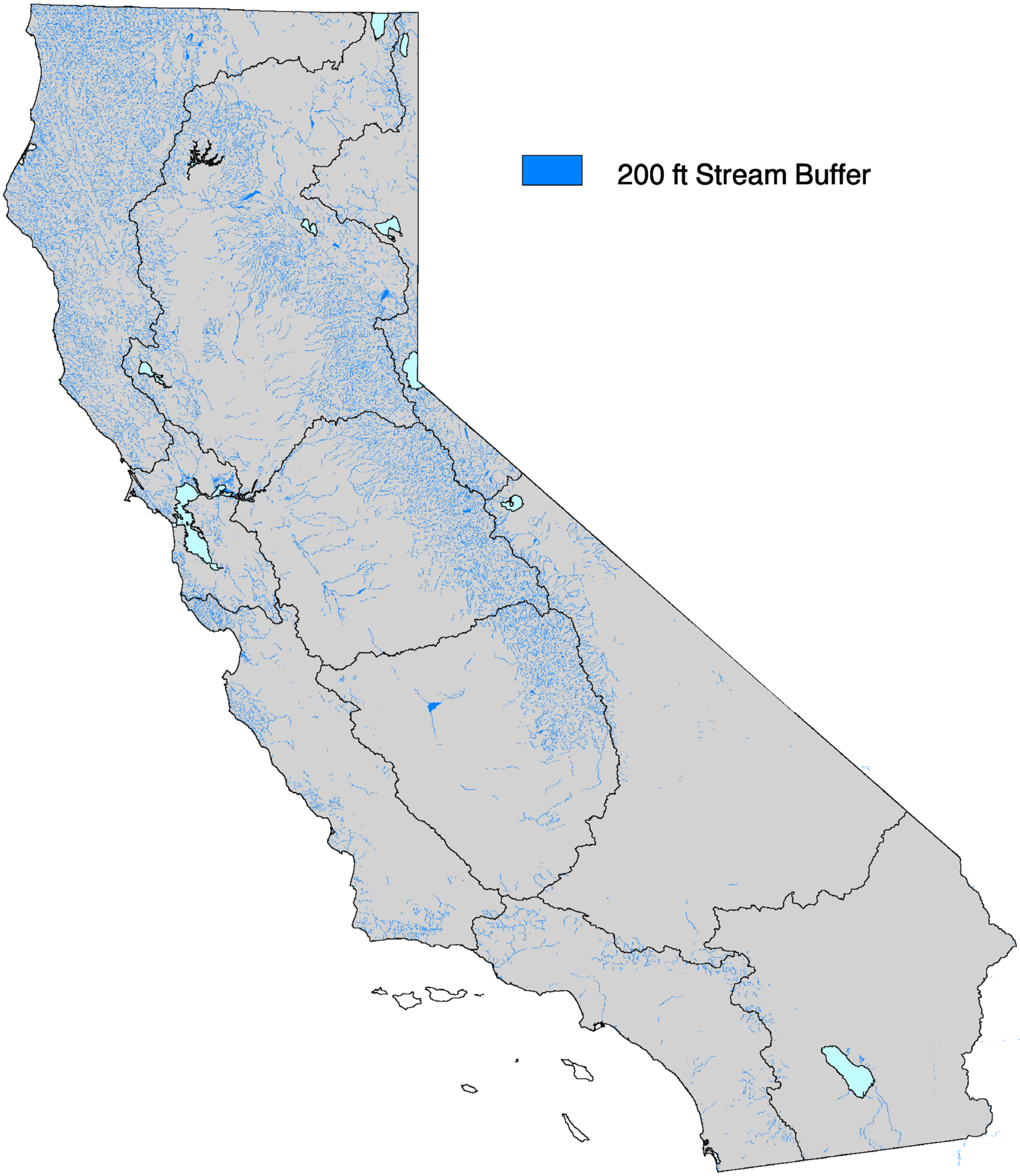
Because establishing quantitative linkages between management actions, alteration of aquatic habitats, and biologic response has had limited success, approximations are often used to identify areas where special protection may be needed. Figure 12 shows the areas of California that correspond to productive forest lands available for timber harvesting (timberlands) with steeper slopes (over 40 percent). Harvesting and other land uses often occur on slopes over 40 percent, but it is reasonable to suggest that increased attention will be paid to such activities if water quality or fish habitat issues are involved. Figure 13 shows areas of California that reflect buffer strips of 200 feet on either side of perennial streams. The distance of 200 feet probably overestimates the area to which additional land use restrictions will apply as part of water quality and fish habitat protection. Still, it is a reasonable first approximation of the increased attention that will be paid to possible land use impacts. In a general sense, both State and federal approaches to protection of beneficial water uses will concentrate protection on steeper slopes and riparian areas near streams. Table 5 indicates the Hardwood and Conifer lands that have over 40 percent slope. Table 6 indicates the area within the 200 foot perennial stream buffer. Table 7 indicates acreage that combines slope and buffer quantities in these categories.

Figure 12. Areas of approximate locations of timberlands with slope greater than 40 percent



Source: FRAP, 2003

Figure 13. Areas with perennial stream buffer (within 200 feet)



Source: FRAP, 2003

Table 5. Area and percentage of Conifer and Hardwood Forests and Woodlands where slope is greater than 40 percent (acres)

DWR region	Conifer Private	Percent	Conifer Public	Percent	Hardwood Private	Percent	Hardwood Public	Percent
Central Coast	46,943	27	54,398	22		1	35,467	9
Colorado River	6,106	11	22,879	9	1,987	26	8,273	56
North Coast	833,704	29	1,920,664	46	367,053	24	309,771	51
North Lahontan	24,416	7	112,408	14	237	4	2,301	17
Sacramento River	327,644	13	830,222	20	144,062	7	234,958	40
San Francisco Bay	32,598	33	12,704	26	27,767	7	6,005	10
San Joaquin	46,053	9	410,617	21	31,190	3	119,270	39
South Coast	7,749	13	131,366	40	7,453	4	64,882	34
South Lahontan	3,497	3	92,805	10	2,454	6	5,377	10
Tulare Lake	18,706	21	478,947	29	20,087	2	131,080	28

Source: FRAP, 2003

Table 6. Area and percentage of Conifer and Hardwood Forests and Woodlands within 200 foot perennial stream buffer (acres)

DWR region	Conifer Private	Percent	Conifer Public	Percent	Hardwood Private	Percent	Hardwood Public	Percent
Central Coast	13,942	8	6,210	3	25,158	2	11,579	3
Colorado River	175	0	1,206	0	366	5	660	4
North Coast	173,804	6	245,909	6	110,167	7	51,944	9
North Lahontan	12,546	4	33,184	4	1,250	22	1,987	15
Sacramento River	117,407	4	173,918	4	77,638	4	39,470	7
San Francisco Bay	6,262	6	3,531	7	12,499	3	3,635	6
San Joaquin	25,479	5	140,544	7	27,873	3	17,626	6
South Coast	1,159	2	6,487	2	6,467	3	9,672	5
South Lahontan	867	1	15,419	2	1,386	3	8,552	16
Tulare Lake	2,081	2	84,189	5	14,258	2	18,980	4

Source: FRAP, 2003

Table 7. Area and percentage of Conifer and Hardwood Forests and Woodlands with slope greater than 40 percent and 200 feet of either side of perennial streams

DWR region	Conifer Private	Percent	Conifer Public	Percent	Hardwood Private	Percent	Hardwood Public	Percent
Central Coast	2,009	1.1	1,248	0.5	405	0.0	744	0.2
Colorado River	52	0.1	264	0.1	35	0.5	200	1.3
North Coast	21,286	0.7	56,535	1.4	10,235	0.7	11,409	1.9
North Lahontan	282	0.1	1,895	0.2	17	0.3	15	0.1
Sacramento River	9,034	0.3	24,019	0.6	4,169	0.2	7,495	1.3
San Francisco Bay	1,008	1.0	418	0.8	319	0.1	57	0.1
San Joaquin	1,216	0.2	11,174	0.6	610	0.1	3,828	1.2
South Coast	62	0.1	1,236	0.4	143	0.1	1,055	0.6
South Lahontan	44	0.0	1,352	0.1	32	0.1	257	0.5
Tulare Lake	114	0.1	11,619	0.7	193	0.0	3,588	0.8

Source: FRAP, 2003

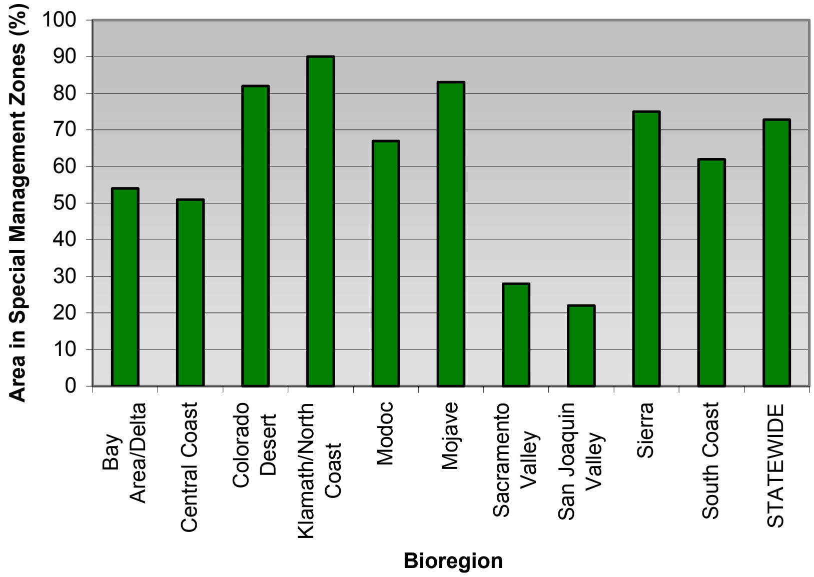
In addition to the slope and perennial stream land characteristics as determinants for special watershed protection, other overlapping regulatory frameworks and legal requirements influence soil and water protection. Examples of such frameworks include reserves, watershed policies by agencies on federal lands, regulatory approaches on privately owned forest lands, and voluntary approaches on privately-owned rangelands (see below). Frequently, these approaches also address maintenance of biological diversity; therefore, it is impossible to separate out the impacts of overlapping frameworks and rules at the Statewide level specifically related to watershed protection.

To approximate the overall impact of regulatory frameworks and legal requirements on protecting watershed and other related values, FRAP rated each bioregion based on the extent of area with regulatory protection requirements. The rating method estimates the percent of forest and rangeland area with at least one specific regulatory requirement or physical lands characteristic where special protection measures are often applied, termed "Special Management Zones". Bioregions with substantial portions of land in these Special Management Zones are likely to result in more attention towards protection of biological diversity, ecosystem structures, and soil and water quality. The following are the regulatory or unique land formations used to identify these zones:

- California Coastal Zone designation;
- Habitat Conservation Plans and Natural Community Conservation Plans;
- public lands;
- reserves (excludes most management);
- forested lands with steeper slopes (over 40 percent);
- perennial stream riparian areas;
- Areas defined as Late Successional Forests (LSF) (as defined by the California Forest Practice Rules);
- watersheds with TMDL plans; and
- voluntary or mandatory county oak ordinances on hardwood range areas.

Of the over 80 million acres of forests and rangelands, 73 percent have at least one of above listed designations or land formation that provides protection of resource values. Profiles of each bioregion show that the highest proportions of Special Management Zones in forests and rangelands are in the Klamath/North Coast (90 percent) and Mojave and Colorado Desert bioregions (over 80 percent) (Figure 14).

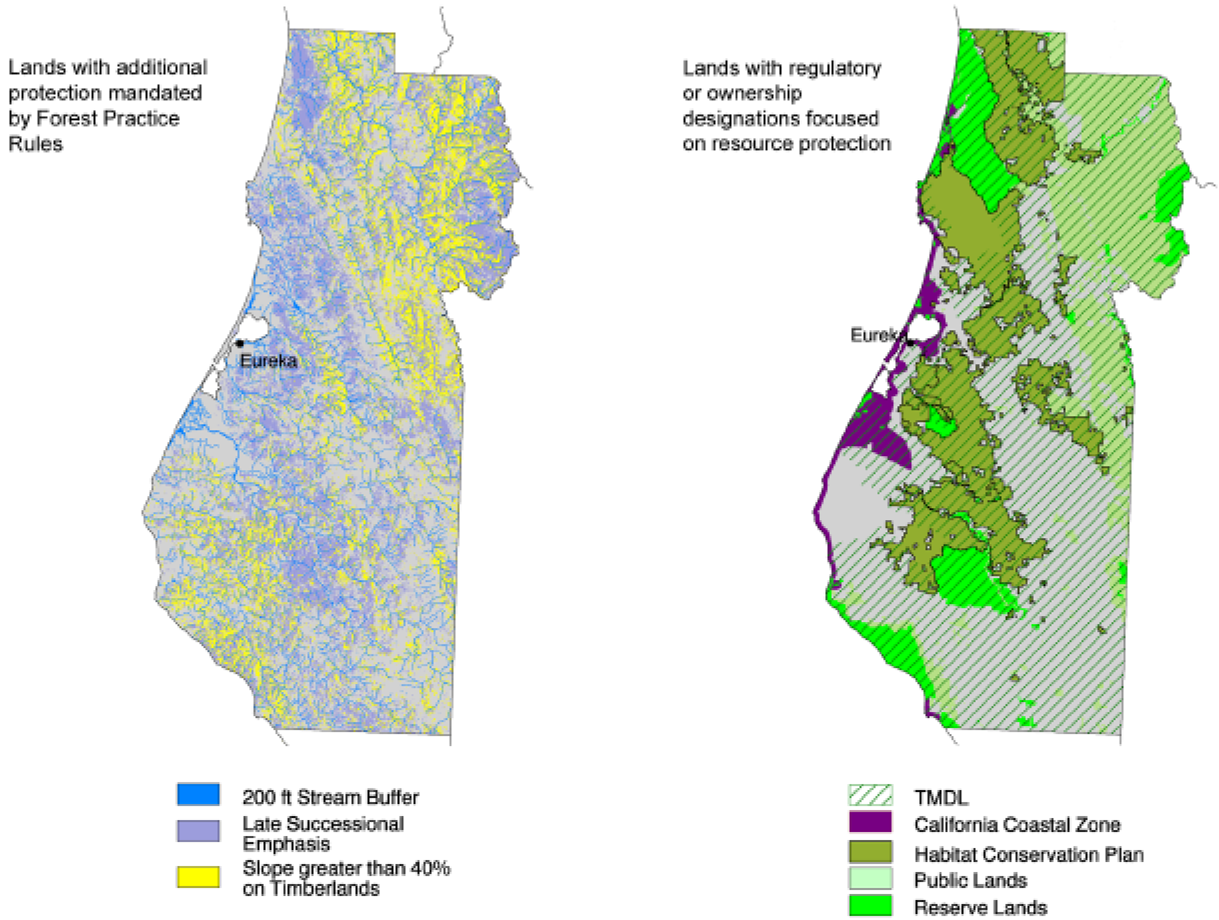
Figure 14. Percentage of forest and rangeland area in Special Management Zones



Source: FRAP, 2003

Results of the analysis suggest that most forests and rangelands where significant management activities occur have some additional regulatory focus or designation that can contribute to the protection of unique habitats, biological diversity, soil and water quality, and aquatic systems. For example, over 90 percent of Humboldt County is in Special Management Zones that can lead to special review for impacts from logging or grazing (Figure 15). However, the extent of government regulation does not necessarily predict the actual level of environmental stewardship and protection.

Figure 15. Regional governance indicator



Source: FRAP, 2003